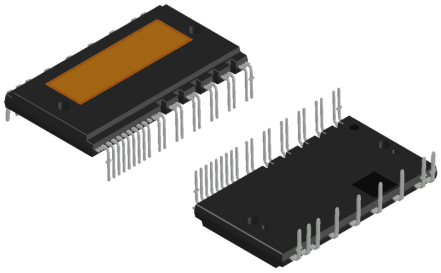
Intelligent Power Module (IPM)

650 V, 20 A

NFAM2065L4BT



DIP39 54.5 x 31.0
CASE MODGC

General Description

The NFAM2065L4BT is a fully−integrated inverter power module consisting of an independent High side gate driver, LVIC, six IGBT's and a temperature sensor (VTS or Thermistor(T)), suitable for driving permanent magnet synchronous (PMSM) motors, brushless DC (BLDC) motors and AC asynchronous motors. The IGBT's are configured in a three−phase bridge with separate emitter connections for the lower legs for maximum flexibility in the choice of control algorithm.

The power stage has under−voltage lockout protection (UVP). Internal boost diodes are provided for high side gate boost drive.

Features

- Three−phase 650 V, 20 A IGBT Module with Independent Drivers
- Active Logic Interface
- Built−in Under−voltage Protection (UVP)
- Integrated Bootstrap Diodes and Resistors
- Separate Low−side IGBT Emitter Connections for Individual Current Sensing of Each Phase
- Temperature Sensor (VTS or Thermistor (T))
- UL1557 Certified (File No.E339285)
- This is a Pb−Free Device

Typical Application

- Industrial Drives
- Industrial Pumps
- Industrial Fans
- Industrial Automation

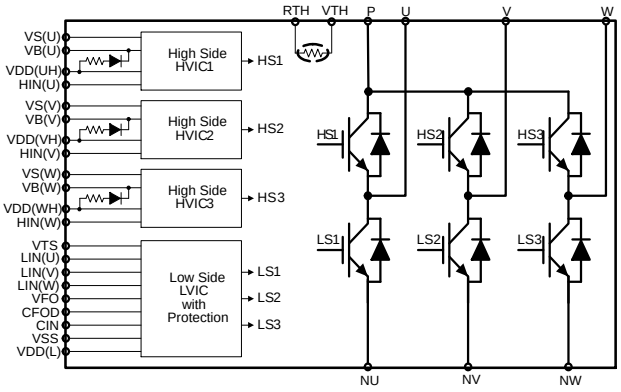
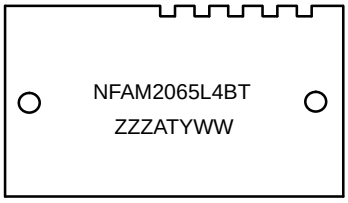


Figure 1. Application Schematic

MARKING DIAGRAM



Device marking is on package top side

NFAM2065L4BT = Specific Device Code
ZZZ = Assembly Lot Code
A = Assembly Location
T = Test Location
Y = Year
WW = Work Week

ORDERING INFORMATION

Device	Package	Shipping (Qty / Packing)
NFAM2065L4BT	DIP39, 31.0x54.5 (Pb−Free)	90 / BOX

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APPLICATION SCHEMATIC

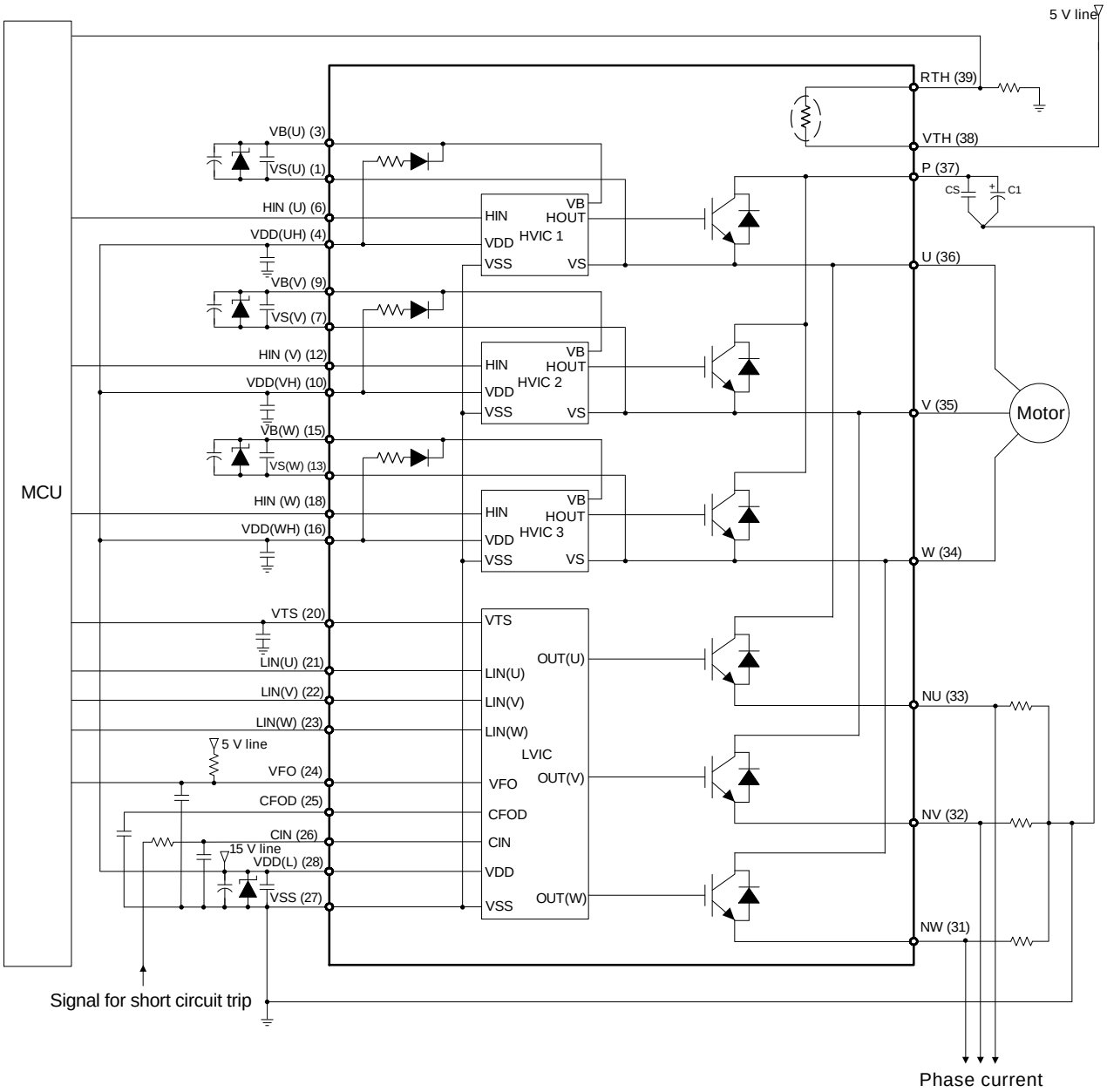


Figure 2. Application Schematic − Adjustable Option

BLOCK DIAGRAM

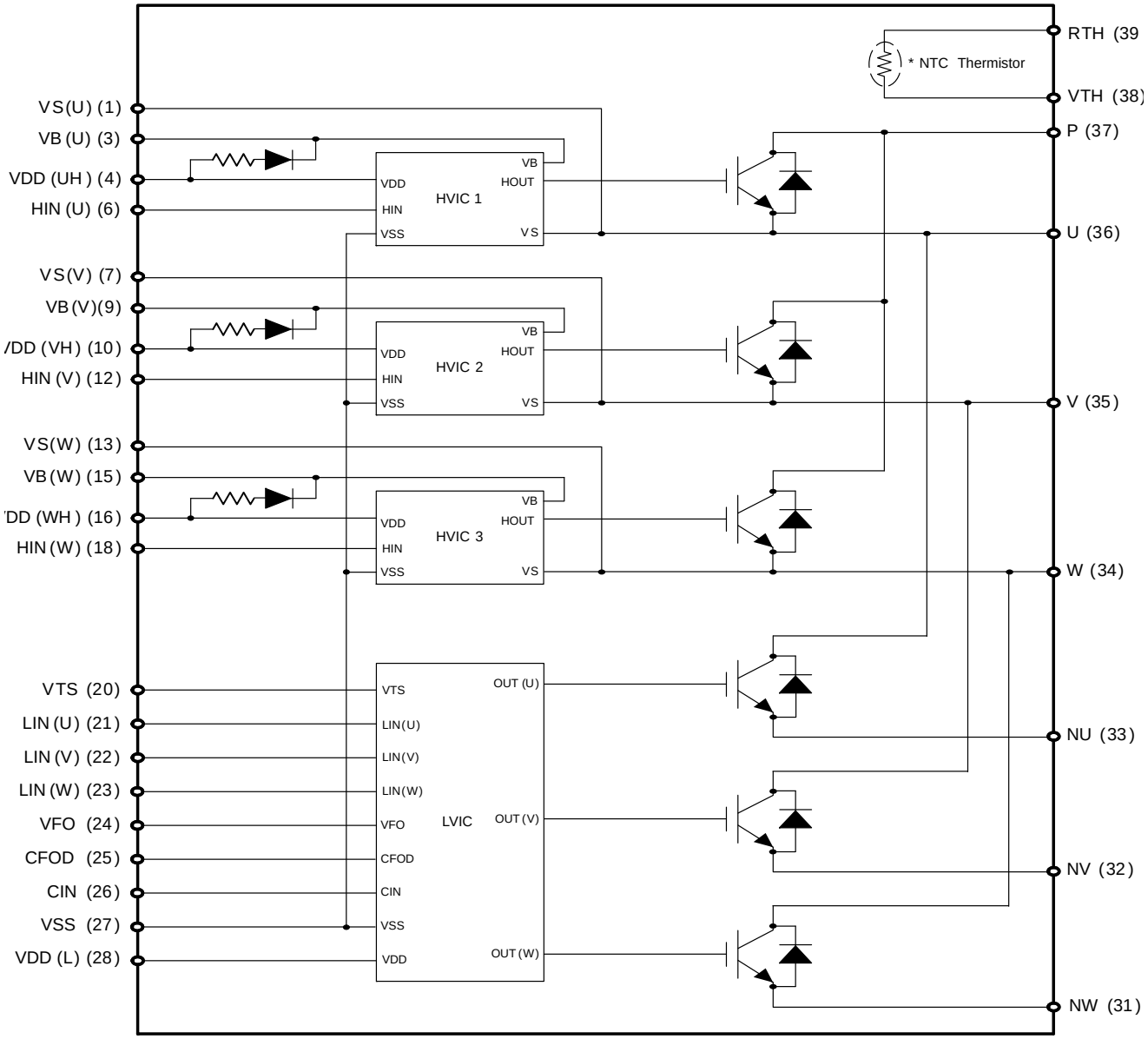


Figure 3. Equivalent Block Diagram

PIN FUNCTION DESCRIPTION

Pin	Name	Description
1	VS(U)	High−Side Bias Voltage GND for U Phase IGBT Driving
(2)	−	Dummy
3	VB(U)	High−Side Bias Voltage for U Phase IGBT Driving
4	VDD(UH)	High−Side Bias Voltage for U Phase IC
(5)	−	Dummy
6	HIN(U)	Signal Input for High−Side U Phase
7	VS(V)	High−Side Bias Voltage GND for V Phase IGBT Driving
(8)	−	Dummy
9	VB(V)	High−Side Bias Voltage for V Phase IGBT Driving
10	VDD(VH)	High−Side Bias Voltage for V Phase IC
(11)	−	Dummy
12	HIN(V)	Signal Input for High−Side V Phase
13	VS(W)	High−Side Bias Voltage GND for W Phase IGBT Driving
(14)	−	Dummy
15	VB(W)	High−Side Bias Voltage for W Phase IGBT Driving
16	VDD(WH)	High−Side Bias Voltage for W Phase IC
(17)	−	Dummy
18	HIN(W)	Signal Input for High−Side W Phase
(19)	−	Dummy
20	VTS	Voltage Output for LVIC Temperature Sensing Unit
21	LIN(U)	Signal Input for Low−Side U Phase
22	LIN(V)	Signal Input for Low−Side V Phase
23	LIN(W)	Signal Input for Low−Side W Phase
24	VFO	Fault Output
25	CFOD	Capacitor for Fault Output Duration Selection
26	CIN	Input for Current Protection
27	VSS	Low−Side Common Supply Ground
28	VDD(L)	Low−Side Bias Voltage for IC and IGBTs Driving
(29)	−	Dummy
(30)	−	Dummy
31	NW	Negative DC−Link Input for U Phase
32	NV	Negative DC−Link Input for V Phase
33	NU	Negative DC−Link Input for W Phase
34	W	Output for U Phase
35	V	Output for V Phase
36	U	Output for W Phase
37	P	Positive DC−Link Input
38	VTH	Thermistor Bias Voltage (T) / Not connection
39	RTH	Series Resister for Thermistor (Temperature Detection) *optional for T

1. Pins of () are the dummy for internal connection. These pins should be no connection.

ABSOLUTE MAXIMUM RATINGS (T_C = 25°C) (Note 2)

Rating	Symbol	Conditions	Value	Unit
Supply Voltage	VPN	P − NU, NV, NW	450	V
Supply Voltage (Surge)	VPN(Surge)	P − NU, NV, NW, (Note 3)	550	V
Self Protection Supply Voltage Limit (Short−Circuit Protection Capability)	VPN(PROT)	VDD = VBS = 13.5 V ~ 16.5 V, Tj = 150°C, Vces < 650 V, Non−Repetitive, < 2 us	400	V
Collector−Emitter Voltage	Vces		650	V
Maximum Repetitive Revers Voltage	VRRM		650	V
Each IGBT Collector Current	±Ic		±20	A
Each IGBT Collector Current (Peak)	±Icp	Under 1 ms Pulse Width	±40	A
Control Supply Voltage	VDD	VDD(UH,VH,WH), VDD(L) − VSS	−0.3 to 20	V
High−Side Control Bias Voltage	VBS	VB(U) − VS(U), VB(V) − VS(V), VB(W) − VS(W)	−0.3 to 20	V
Input Signal Voltage	VIN	HIN(U), HIN(V), HIN(W), LIN(U), LIN(V), LIN(W) − VSS	−0.3 to VDD	V
Fault Output Supply Voltage	VFO	VFO − VSS	−0.3 to VDD	V
Fault Output Current	IFO	Sink Current at VFO pin	2	mA
Current Sensing Input Voltage	VCIN	CIN − VSS	−0.3 to VDD	V
Corrector Dissipation	Pc	Per One Chip	96	W
Operating Junction Temperature	Tj		−40 to +150	°C
Storage Temperature	Tstg		−40 to +125	°C
Module Case Operation Temperature	Tc		−40 to +125	°C
Isolation Voltage	Viso	60 Hz, Sinusoidal, AC 1 minute, Connection Pins to Heat Sink Plate	2500	V rms

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

2. Refer to ELECTRICAL CHARACTERISTICS, RECOMMENDED OPERATING RANGES and/or APPLICATION INFORMATION for Safe Operating parameters.
3. This surge voltage developed by the switching operation due to the wiring inductance between P and NU, NV, NW terminal.

THERMAL CHARACTERISTICS

Rating	Symbol	Conditions	Min	Typ	Max	Unit
Junction to Case Thermal Resistance	Rth(j−c)Q	Inverter IGBT Part (per 1/6 Module)	−	−	1.3	°C/W
	Rth(j−c)F	Inverter FWDi Part (per 1/6 Module)	−	−	2.4	°C/W

4. Refer to ELECTRICAL CHARACTERISTICS, RECOMMENDED OPERATING RANGES and/or APPLICATION INFORMATION for Safe Operating parameters.

RECOMMENDED OPERATING RANGES (Note 5)

Rating	Symbol	Conditions		Min	Typ	Max	Unit
Supply Voltage	VPN	P − NU, NV, NW		−	300	400	V
Gate Driver Supply Voltages	VDD	VDD(UH,VH,WH), VDD(L) − VSS		13.5	15	16.5	V
	VBS	VB(U) − VS(U), VB(V) − VS(V), VB(W) − VS(W)		13.0	15	18.5	V
Supply Voltage Variation	dVDD / dt dVBS / dt			−1	−	1	V/μs
PWM Frequency	fPWM			1		20	kHz
Dead Time	DT	Turn−off to Turn−on (external)		1.5	−	−	μs
Allowable r.m.s. Current	Io	VPN = 300 V, VDD = VD = 15 V, P.F. = 0.8, Tc ≤ 125°C, Tj ≤ 150°C, (Note 5)	fPWM = 5 kHz	−	−	20.5	A rms
			fPWM = 15 kHz	−	−	15.4	

RECOMMENDED OPERATING RANGES (Note 5) (continued)

Rating	Symbol	Conditions	Min	Typ	Max	Unit
Allowable Input Pulse Width	PWIN (on)	200 V ≤ VPN ≤ 400 V, 13.5 V ≤ VDD ≤ 16.5 V, 13.0 V ≤ VBS ≤ 18.5 V, −20°C ≤ Tc ≤ 100°C	1.0	−	−	μs
	PWIN (off)		1.5	−	−	
Package Mounting Torque		M3 Type Screw	0.6	0.7	0.9	Nm

Functional operation above the stresses listed in the Recommended Operating Ranges is not implied. Extended exposure to stresses beyond the Recommended Operating Ranges limits may affect device reliability.

5. Allowable r.m.s Current depends on the actual conditions.
6. Flatness tolerance of the heatsink should be within −50 μm to +100 μm.

ELECTRICAL CHARACTERISTICS (Tc = 25°C, VDD = 15 V, VBS = 15 V, unless otherwise noted) (Note 7)

Parameter		Test Conditions	Symbol	Min	Typ	Max	Unit
INVERTER SECTION							
Collector−Emitter Leakage Current		Vce = Vces, Tj = 25°C	Ices	−	−	1	mA
		Vce = Vces, Tj = 150°C		−	−	10	mA
Collector−Emitter Saturation Voltage		VDD = VBS = 15 V, IN = 5 V Ic = 20 A, Tj = 25°C	VCE(sat)	−	1.60	2.30	V
		VDD = VBS = 15 V, IN = 5 V Ic = 20 A, Tj = 150°C		−	1.80	−	V
FWDi Forward Voltage		IN = 0 V, If = 20 A, Tj = 25°C	VF	−	1.90	2.30	V
		IN = 0 V, If = 20 A, Tj = 150°C		−	1.90	−	V
High Side	Switching Times	VPN = 300 V, VDD(H) = VDD(L) = 15 V Ic = 20 A, Tj = 25°C, IN = 0 ⇔ 5 V Inductive Load	ton	0.80	1.30	1.90	μs
			tc (on)	−	0.20	0.60	μs
			toff	−	1.40	2.00	μs
			tc (off)	−	0.20	0.70	μs
			trr	−	0.15	−	μs
Low Side	Switching Times	VPN = 300 V, VDD(H) = VDD(L) = 15 V Ic = 20 A, Tj = 25°C, IN = 0 ⇔ 5 V Inductive Load	ton	0.80	1.40	2.00	μs
			tc (on)	−	0.20	0.60	μs
			toff	−	1.50	2.10	μs
			tc (off)	−	0.20	0.70	μs
			trr	−	0.15	−	μs

DRIVER SECTION

Quiescent VDD Supply Current	VDD(UH,VH,WH) = 15 V, HIN(U,V,W) = 0 V	VDD(UH) − VSS VDD(VH) − VSS VDD(WH) − VSS	IQDDH	−	−	0.30	mA
	VDD(L) = 15 V, LIN(U, V, W) = 0 V	VDD(L) − VSS	IQDDL	−	−	3.50	mA
Operating VDD Supply Current	VDD(UH, VH, WH) = 15 V, fPWM = 20 kHz, Duty = 50%, Applied to one PWM Signal Input for High−Side	VDD(UH) − VSS VDD(VH) − VSS VDD(WH) − VSS	IPDDH	−	−	0.40	mA
	VDD(L) = 15 V, fPWM = 20 kHz, Duty = 50%, Applied to one PWM Signal Input for Low−Side	VDD(L) − VSS	IPDDL	−	−	6.00	mA
Quiescent VBS Supply Current	VBS = 15 V HIN(U, V, W) = 0 V	VB(U) − VS(U) VB(V) − VS(V) VB(W) − VS(W)	IQBS	−	−	0.30	mA

ELECTRICAL CHARACTERISTICS (Tc = 25°C, VDD = 15 V, VBS = 15 V, unless otherwise noted) (Note 7) (continued)

Parameter	Test Conditions		Symbol	Min	Typ	Max	Unit
DRIVER SECTION							
Operating VBS Supply Current	VDD = VBS = 15 V, fPWM = 20 kHz, Duty = 50%, Applied to one PWM Signal Input for High−Side	VB(U) − VS(U) VB(V) − VS(V) VB(W) − VS(W)	IPBS	−	−	5.00	mA
ON Threshold Voltage	HIN(U, V, W) − VSS, LIN(U, V, W) − VSS		VIN(ON)	−	−	2.6	V
OFF Threshold Voltage			VIN(OF)	0.8	−	−	V
Short Circuit Trip Level	VDD = 15 V, CIN−VSS		VCIN(ref)	0.46	0.48	0.50	V
Supply Circuit Under−Voltage Protection	Detection Level		UVDDD	10.3	−	12.5	V
	Reset Level		UVDDR	10.8	−	13.0	V
	Detection Level		UVBSD	10.0	−	12.0	V
	Reset Level		UVBSR	10.5	−	12.5	V
Voltage Output for LVIC Temperature Sensing Unit	VTS−VSS = 10 nF, Temp. = 25°C		VTS	0.905	1.030	1.155	V
Fault Output Voltage	VDD = 0 V, CIN = 0 V, VFO Circuit: 10 kΩ to 5 V Pull−up		VFOH	4.9	−	−	V
	VDD = 0 V, CIN = 1 V, VFO Circuit: 10 kΩ to 5 V Pull−up		VFOL	−	−	0.95	V
Fault−Output Pulse Width	CFOD = 22 nF		tFOD	1.6	2.4	−	ms
BOOTSTRAP SECTION							
Bootstrap Diode Forward Voltage	If = 0.1 A		VF	3.4	4.6	5.8	V
Built−in Limiting Resistance			RBOOT	30	38	46	Ω

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

7. Performance guaranteed over the indicated operating temperature range by design and/or characterization tested at $T_J = T_A = 25°C$. Low duty cycle pulse techniques are used during testing to maintain the junction temperature as close to ambient as possible.
8. The fault−out pulse width tFOD depends on the capacitance value of CFOD according to the following approximate equation: $tFOD = 0.11 \times 10^6 \times CFOD$ (s).
9. Values based on design and/or characterization.

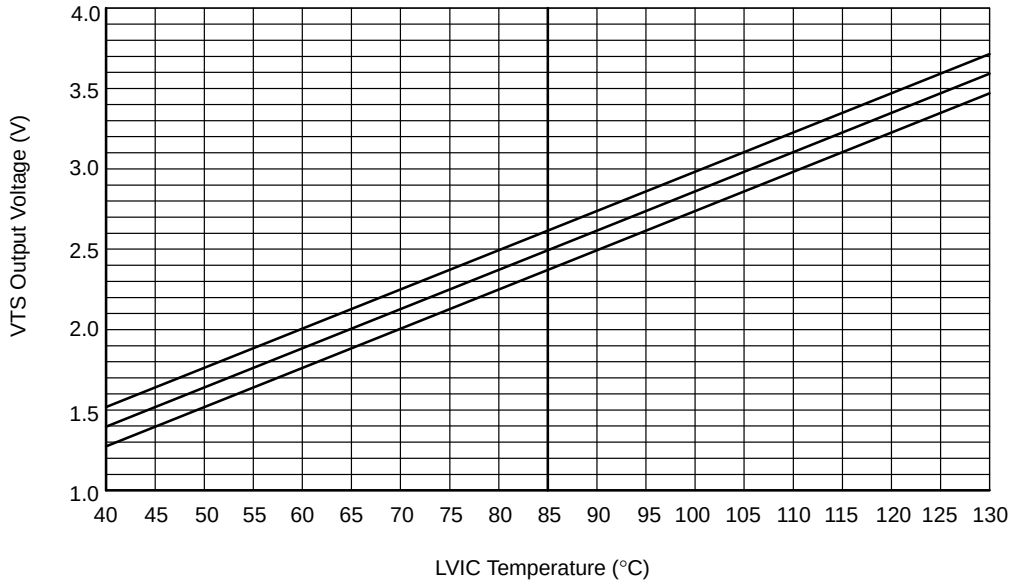


Figure 4. Temperature of LVIC versus VOT Characteristics

THERMISTOR CHARACTERISTIC

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Resistance	R_{25}	Tc = 25°C	46.530	47	47.47	kΩ
Resistance	R_{125}	Tc = 100°C	1.344	1.406	1.471	kΩ
B−Constant (25−50°C)	−	B	4009.5	4050	4090.5	K
Temperature Range	−	−	−40	−	+125	°C

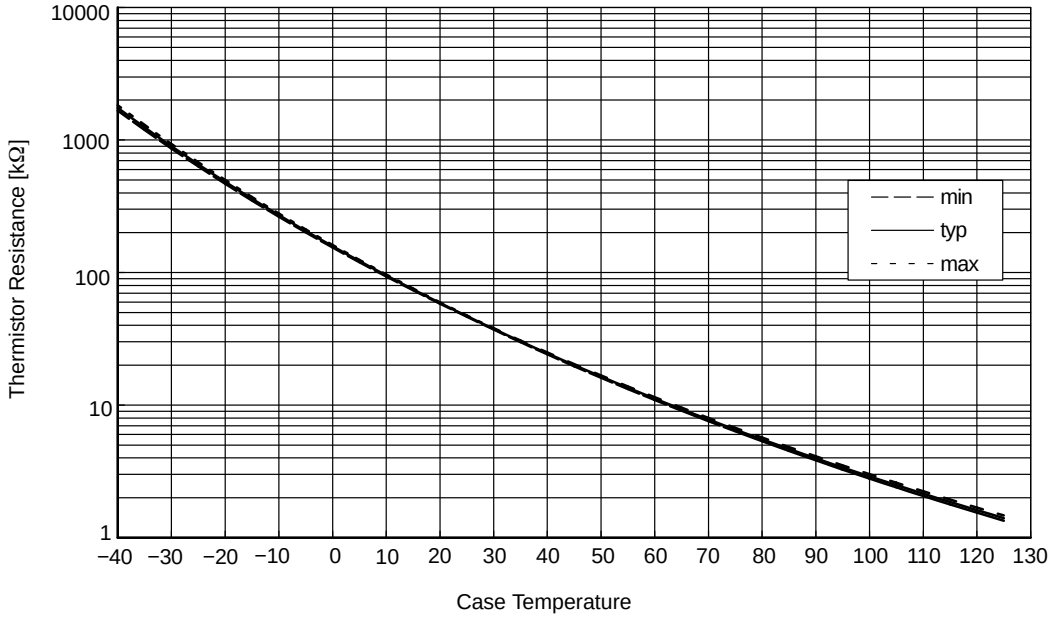
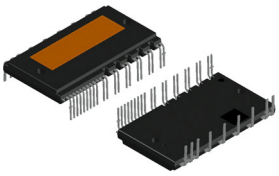


Figure 5. Thermistor Resistance versus Case Temperature

MECHANICAL CASE OUTLINE
PACKAGE DIMENSIONS



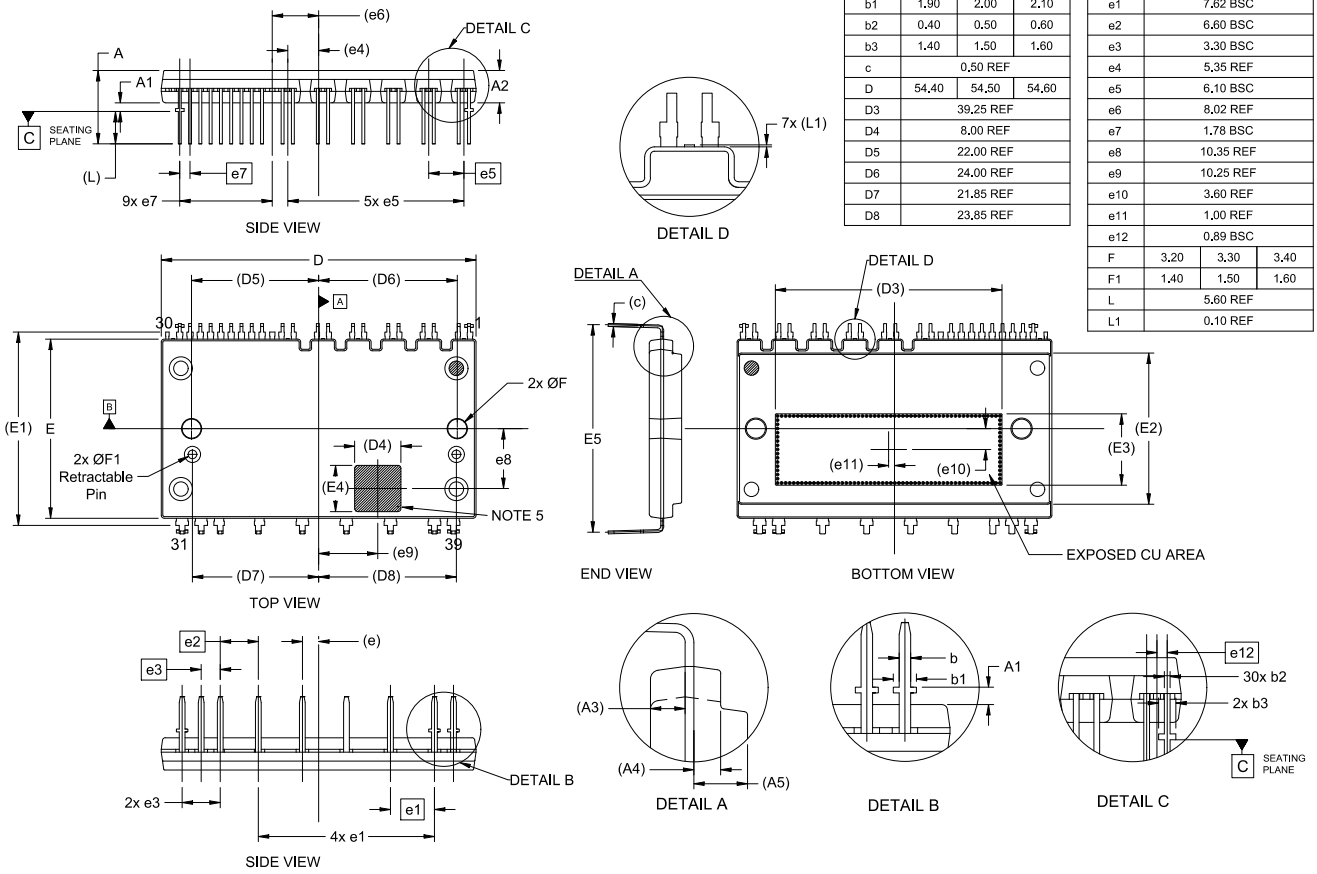
DIP39, 54.50x31.00x5.60, 1.78P
CASE MODGC
ISSUE B

DATE 21 DEC 2023

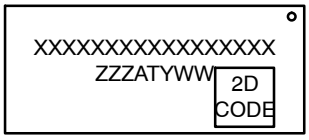
NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 2009.
2. CONTROLLING DIMENSION: MILLIMETERS
3. DIMENSION b and c APPLY TO THE PLATED LEADS AND ARE MEASURED BETWEEN 1.00 AND 2.00 FROM THE LEAD TIP
4. POSITION OF THE LEAD IS DETERMINED AT THE BASE OF THE LEAD WHERE IT EXITS THE PACKAGE BODY
5. AREA FOR 2D BAR CODE
6. SHORTENED/CUT PINS ARE 2,5,8,11,14,17,19,29 AND 30

DIM	MILLIMETERS		
	MIN.	NOM.	MAX.
A	12.20	12.7	13.2
A1	1.00	1.50	2.00
A2	5.50	5.60	5.70
A3		2.00 REF	
A4		1.55 REF	
A5		3.10 REF	
b	0.90	1.00	1.10
b1	1.90	2.00	2.10
b2	0.40	0.50	0.60
b3	1.40	1.50	1.60
c		0.50 REF	
D	54.40	54.50	54.60
D3		39.25 REF	
D4		8.00 REF	
D5		22.00 REF	
D6		24.00 REF	
D7		21.85 REF	
D8		23.85 REF	

DIM	MILLIMETERS		
	MIN.	NOM.	MAX.
E	30.90	31.00	31.10
E1		33.50 REF	
E2		26.14 REF	
E3		12.35 REF	
E4		8.00 REF	
E5	35.40	35.90	36.40
e		2.81 REF	
e1		7.62 BSC	
e2		6.60 BSC	
e3		3.30 BSC	
e4		5.35 REF	
e5		6.10 BSC	
e6		8.02 REF	
e7		1.78 BSC	
e8		10.35 REF	
e9		10.25 REF	
e10		3.60 REF	
e11		1.00 REF	
e12		0.89 BSC	
F	3.20	3.30	3.40
F1	1.40	1.50	1.60
L		5.60 REF	
L1		0.10 REF	



GENERIC MARKING DIAGRAM*



XXXXX = Specific Device Code
ZZZ = Assembly Lot Code
AT = Assembly & Test Location
Y = Year
WW = Work Week

*This information is generic. Please refer to device data sheet for actual part marking. Pb−Free indicator, “G” or microdot “ ▪”, may or may not be present. Some products may not follow the Generic Marking.

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